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Inventor(s): **Dwight J. Petruchik**

Attorney: **Raymond L. Owens**

PROCESS FOR LAMINATING ELECTRICALLY ADDRESSABLE DISPLAY

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CROSS REFERENCE TO RELATED APPLICATION

Reference is made to commonly-assigned U.S. Patent Application Serial No. _____ filed concurrently herewith, entitled "Selective Removal of Light Modulating Layer From Electrically Conductive Layer of Liquid Crystal Display Structure" by Dwight J. Petruchik, the disclosure of which is incorporated herein.

FIELD OF THE INVENTION

The present invention relates to electrically addressable displays and, more particularly, to a process for laminating a flexible electrically addressable display material to produce an image display of high strength and good durability.

BACKGROUND OF THE INVENTION

Liquid crystalline materials, because they can be manipulated between light scattering and light transmissive modes in response to applied electric fields, find use in a variety of display devices. These materials, which may have either positive or negative dielectric anisotropy, are generally classified as nematic or smectic. A particular type of nematic liquid crystals, referred to as chiral nematic, has the ability to selectively reflect one component of circularly polarized light. In the chiral nematic phase, which is synonymous with the cholesteric phase, chiral molecules form very thin layers of aligned molecules, the alignment in one layer being at a slight angle from that in an adjacent layer, and the alignment in a stack of such layers forming a continuous helical pattern.

Many known liquid crystal display devices make use of liquid crystalline materials dispersed in polymeric matrices. For example, U.S. Patent No. 4,435,047, the disclosure of which is incorporated herein by reference, describes a liquid crystalline material, preferably nematic, of positive dielectric anisotropy dispersed in a polymeric encapsulating medium such as polyvinyl alcohol. Also, U.S. Patent No. 4,685,771, the disclosure of which is incorporated herein by reference, describes a light-modulating liquid crystal display material

that contains liquid crystalline microdroplets dispersed in a thermoplastic resin, the microdroplets being of a size effective to scatter incident light when the optical axes of the microdroplets are randomly aligned. U.S. Patent No. 5,116,528, the disclosure of which is incorporated herein by reference, describes a light modulating material that includes a liquid crystalline material dispersed in a cross-linked isocyanate material, preferably a polyacrylic urethane. Also, U.S. Patent No. 5,583,670, the disclosure of which is incorporated herein by reference, describes an information recording layer in which a liquid crystal phase is dispersed in an acrylic or methacrylic resin having a molecular weight of 25,000 to 100,000.

PCT/WTO 97/04398, entitled ELECTRONIC BOOK WITH MULTIPLE DISPLAY IMAGES, discloses the assembly of multiple electronically written display sheets into a "book." The reference describes prior art techniques for forming thin, electronically written pages, including flexible sheets, image modulating material formed from a bi-stable liquid crystal system, thin metallic conductor lines on each page, and transparent conducting polymers formed over the light modulating material.

Co-pending, commonly assigned U.S. Application Serial No. 09/379,776, filed August 24, 1999 for FORMING A DISPLAY HAVING CONDUCTIVE IMAGE AREAS OVER A LIGHT MODULATING LAYER, the disclosure of which is incorporated herein by reference, describes a method for forming a display on a transparent substrate on which is formed a transparent, electrically conductive coating. A light modulating layer including liquid crystal material in a polymer binder is formed over the electrically conductive layer, and an opaque conductive material is deposited in an imagewise pattern over the light modulating layer in the form of viewable and conductive images. The light modulating layer is effective in a first condition to prevent the viewing of the viewable and conductive images and in a second condition to permit the viewing of the viewable and conductive images. Electrical connections enable an electrical field to be applied across selected ones of the viewable and conductive images and the transparent electrically conductive layer to cause the light

modulating layer underlying the selected images to change from the first condition to the second condition and thereby present the images for viewing by a viewer.

There is a need for incorporating electrically addressable displays, in particular, those formed on a thin, flexible substrate, into a wide variety of durable devices, for example, credit cards, telephone cards, signs, clocks, advertising devices, and the like. Such display devices must be able to withstand or mitigate damage caused by, for example, abrasion, impact, and various environmental factors.

SUMMARY OF THE INVENTION

The present invention is directed to a process for laminating a flexible electrically addressable display that comprises: providing a flexible, electrically addressable liquid crystal display having first and second surfaces, placing a protective sheet over at least one of the first and second surfaces, and subjecting the protective sheet to conditions of temperature and pressure effective to cause the protective sheet to adhere to the surface, thereby forming a laminate that comprises the electrically addressable liquid crystal display.

Further, an electrically addressable liquid crystal display made in accordance with the present invention includes a laminate which comprises a flexible substrate on which is formed a transparent, first electrically conductive layer. A light modulating layer comprising liquid crystalline material and a polymeric binder is disposed on the electrically conductive layer, and a patterned layer comprising areas of opaque electrically conductive material is formed on the light modulating layer. A dielectric layer that comprises contact apertures to the areas of opaque electrically conductive material and to the first electrically conductive layer is disposed on the patterned layer, and a second electrically conductive layer overlying the dielectric layer extends into the contact apertures to the areas of opaque electrically conductive material and the first electrically conductive layer.

The laminate enables displays to withstand damage caused by abrasion, impact and various environmental factors.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B schematically depict the process of the present invention for laminating an electrically addressable liquid crystal display between two protective sheets;

FIGS. 2A and 2B depict a further embodiment of the process of the invention in which the laminate further includes printed sheets; and

FIG. 3 is a schematic cross-sectional view of an electrically addressable liquid crystal display useful in the practice of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As illustrated in FIGS. 1A and 1B, an electrically addressable liquid crystal display 11 is placed between protective sheets 12 and 13, and the resulting assembly is passed between two heated laminating rollers R1 and R2 to form a laminate 14 that includes display 11, which is viewable through display window 15. Protective sheet 13 includes a contact aperture 16 to enable electrical contact with display 11. If display 11 includes a durable substrate, as described in the discussion of FIG. 3 below, protective sheet 12, which would be in contact with that substrate, may be omitted.

Laminating rollers R1 and R2 provide sufficient heat and pressure to cause protective sheets 12 and 13 to adhere to each other and to display 11 to form laminate 14. Heating is preferably carried out at a temperature of about 25EC to about 150EC , together with an applied pressure of about 1 kg/cm^2 to about 5 kg/cm^2. An adhesive resin 17, which may be either a homopolymer or co-polymer adhesive resin, is preferably applied to one or both of inner surfaces 18 and 19 of sheets 12 and 13, respectively, to ensure strong lamination.

Protective sheets 12 and 13 may be formed from various materials, for example, polyesters, polyolefins, polycarbonates, vinyl resins, acrylic resins, and methacrylic resins.

FIGS. 2A and 2B depict a process similar to that of FIGS. 1A and 1B, except a printed sheet 21 is inserted between protective sheet 12 and display 11. Optionally, a second printed sheet 22 may be inserted between protective sheet 13 and display 11. A spacer 23 may also be insert between printed sheets 21 and 22 to form a laminate 24.

Depending on the intended application of laminate 24 as, for example, a bank credit or debit card, a telephone card, a sign, a clock, or an advertising display, printed sheets 21 and 22 may include text, illustrations, or logos.

FIG. 3 is a cross-sectional view of an electrically addressable liquid crystal display 30 that can be beneficially employed as display 11 in the above-described laminates 14 and 24. Liquid crystal display 30, which is described in the previously cited U.S. Application Serial No. 09/379,776, filed August 24, 1999 for FORMING A DISPLAY HAVING CONDUCTIVE IMAGE AREAS OVER A LIGHT MODULATING LAYER, includes a flexible substrate 31, preferably comprising polyester, and a transparent, first electrically conductive layer 32, preferably of indium-tin oxide (ITO), disposed on substrate 31.

A light modulating layer 33 comprising liquid crystalline material, preferably a cholesteric material, and a polymeric binder, preferably deionized gelatin, is disposed on electrically conductive layer 32. A patterned layer comprising areas 34 of opaque electrically conductive material is disposed on light modulating layer 33. The opaque material in areas 34 preferably comprises electrically conductive ink, which can be applied by various printing techniques, for example, screen, ink jet, or offset printing.

A dielectric layer 35 disposed on the patterned layer comprising areas 34 contact apertures 36 to areas 34 of opaque electrically conductive material and to first electrically conductive layer 32. (The aperture to conductive layer 32 is not shown.) A second electrically conductive layer 37 overlies dielectric layer 35 and extends into contact apertures 36 to areas 34 of opaque electrically conductive material and to first electrically conductive layer 32.

The invention has been described in detail for the purpose of illustration, but it is to be understood that such detail is solely for that purpose, and variations can be made by those skilled in the art without departing from the spirit and scope of the invention, which is defined by the following claims.

PARTS LIST

R1	laminating roller
R2	laminating roller
11	liquid crystal display
12	protective sheet
13	protective sheet
14	laminate
17	adhesive resin
18	inner surface
19	inner surface
21	printed sheet
22	printed sheet
23	spacer
24	laminate
30	display
31	substrate
32	electrically conductive layer
33	light modulating layer
34	areas
35	dielectric layer
36	apertures
37	electrically conductive layer